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LEVEL II

ECONOMIES OF SCALE IN AIR FORCE
UNDERGRADUATE PILOT TRAINING

Thomas J. Fritzinger, Major, USAF

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The Air Force undergraduate pilot training program was examined to determine whether economies or diseconomies of scale existed in the production of undergraduate pilots. The study used the training costs and output data associated with all training bases from FY 68 through FY 79. Cross-sectional data was used to determine the long run average cost (LAC) curve for each fiscal year, and time-series data was used to determine the LAC curve for each base and the aggregate of all bases. Four models (linear, quadradic, logarithmic, and power) were evaluated by the regression analysis technique to determine which model provided the best fitting LAC curve to the empirical observations. The results indicated that the power model provided the best fitting relationship for the cross-sectional data, and the logarithmic model provided the best fitting relationship for the time-series data. The resultant LAC curves displayed an inverse relationship between average cost and graduate pilot production in all cases. This confirmed the existence of economies of scale in pilot production over the years studied. The inverse relationship also implied that this consolidation of training bases during this period resulted in a decreased average cost per graduate pilot.

LSSR 80-80

ECONOMIES OF SCALE IN AIR FORCE UNDERGRADUATE PILOT TRAINING

A Thesis

Presented to the Faculty of the School of Systems and Logistics

of the Air Force Institute of Technology

Air University

In Partial Fulfillment of the Requirements for the

Degree of Master of Science in Systems Management

By

Thomas J. Fritzinger, BS
Major, USAF

September 1980

This thesis, written by

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and approved in oral examination, has been accepted by the undersigned on behalf of the faculty of the School of Systems and Logistics in partial fulfillment of the requirements for the degree of

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CHAPTER I

INTRODUCTION

Since the beginning of the Vietnam conflict, there has been a steady shift of sentiment away from defense spending toward spending on social welfare programs causing a shrinking budget for the Department of Defense (DOD) (12:61). For example, in 1965, the defense budget accounted for 40.1 percent of all federal outlays as compared to 23.5 percent in 1976 (16:370, 371). From 1976 through 1978, the defense budget remained fairly constant at around 24 percent of all federal outlays (16:370, 371). Expressed in constant 1969 dollars, defense outlays peaked at $83 billion in fiscal year 1968 and then fell more than $30 billion to $51 billion in 1975 (12:61). There are indications that this downward trend will reverse. For example, President Carter has stated that he wants a 3 percent real annual growth in the defense budget through 1984 (4:26). However, defense spending will probably be under the close scrutiny of Congress and the general public for many years to come.

One method the DOD uses to operate under a shrinking defense budget and still maintain a viable defense is to close down operational installations and/or deactivate operational units in order to consolidate resources. One

such action occurred in 1977 with the closure of Kincheloe AFB, Michigan. By closing Kincheloe, the 449th Bombardment Wing and its supporting organizations were deactivated. The operational resources were transferred to other operating units at Ellsworth AFB, K. I. Sawyer AFB, and the Air Force Reserve (6:ii). The main reason stated for this action was the reduction of excess basing capacity and the consequent reduction in support personnel thereby conserving resources while maintaining credible combat capability (6:ii).

An example of deactivating an operational unit while leaving the base installation open occurred at Loring AFB, Maine. In this particular case, the 42d Bombardment Wing and its supporting operational and maintenance squadrons were deactivated. Once again the operational resources were transferred to other operational units and the Air Force Reserve, but the base installation remained open to provide a forward operating location for the Air Force Reserve (5:5).

This particular method of resource conservation was not limited to the Strategic Air Command as the two previous examples may suggest. The Air Training Command used the same rationale for closing Craig AFB, Webb AFB, Moody AFB, and Laredo AFB in the 1970s. For example, in the Secretary of the Air Force decision to close Craig AFB, he stated that Craig's closure "... would narrow a potential difference

between training output and capacity and provide potential manpower and dollar cost avoidances of about 1300 spaces and $24 million [7:2]."

Statement of Problem

The DOD's rationale for deactivating operational units and closing installations due to excess capacity is based on the principle of eliminating the fixed costs associated with the closing base and/or deactivated unit, and allocating the remaining bases and/or units fixed costs over a larger output. This rationale for resource conservation is valid if the economic principle of "economies of scale" exists. In other words, the bases and/or units that remained open would have to be operating on the decreasing segment of their long run average cost curve. However, it is possible that the DOD could actually increase their costs per unit of output at the remaining operational installations and/or units after a consolidation effort due to the principle of "diseconomies of scale". If diseconomies take effect, the DOD would be wasting resources just as they were in the instance of excess capacity. Ideally, the DOD wants to produce its output (national defense) at an operating capacity that minimizes the cost associated with a certain level of output or alternatively, maximize the output associated with a certain level of cost. To accomplish this, the combination of units engaged in producing the same

output should use the operating capacity that produces the desired output at the lowest per unit costs. Therefore, the problem for the DOD is to know whether the consolidation of producing facilities will result in increased efficiency by realizing the effects of economies of scale.

A review of available literature and government reports indicates that this particular problem has not been addressed. The problem needs to be considered because if the DOD could determine with a greater degree of certainty that the consolidation of production resources avoids diseconomies, the DOD could operate with a greater degree of efficiency. To examine this problem, the production of undergraduate pilots within the Air Force will be studied. Pilot production was chosen because of the writer's familiarity with the pilot training operation. More importantly, the undergraduate pilot training operation produces a homogeneous output over a wide range of installations, and is an example of a production effort in the DOD environment.

Objective

The objective of this thesis is to examine the following hypotheses:

1. Economies of scale exist in the production of pilots within the Air Force.

2. The consolidation of pilot training operations results in decreased unit costs for the output produced.

Scope

This study will concentrate on the Air Force's production of undergraduate pilots from FY 1968 through FY 1979. The years 1968 through 1979 were chosen because the production output and associated cost data could be obtained. Also, during these years the production quota for undergraduate pilots varied substantially resulting in the opening and closing of several installations. For example, pilot production went from a high of 4322 in FY 71 to a low of 1132 in FY 79, and the number of installations went from a high of ten in FY 71 to a low of five in FY 78. This variation in output and production facilities should enhance the study's validity.

This study will consider all costs which are relevant to the training of an undergraduate pilot in determining whether economies and/or diseconomies exist in analyzing the results of installation closures and/or unit deactivations. Cost categories will be discussed in Chapter III. Because political and environmental factors which can influence the decision on a base closure are not relevant to the scope of this study, they will not be addressed. Also, due to the dynamic nature of the pilot training operation, there were technological changes and factor input price changes which made cost comparisons difficult. Where possible,

adjustment factors to account for these variations will be applied to prevent a distortion in the cost data.

Organization of the Study

The next chapter will present the economic theory and principles which serve as the basis for this study. Included in the chapter is a discussion of what causes economies and diseconomies of scale to occur along with some industrial examples. Also, the concepts of an organization's cost function and production function will be presented and related to economies and diseconomies of scale.

Chapter III will cover the analytical methods used and the problems associated with determination of an organization's cost function. Also, the sources of relevant cost data and how the data was accumulated will be presented. The remainder of the chapter will cover the computer methodology used to apply the cross-section and time-series regression techniques to the source data.

Chapter IV analyzes the data and regression models used, and presents the results from the cross-sectional and time-series regression analyses. The results are then compared to the study's two hypotheses.

The final chapter provides a summary of the study along with any conclusions reached through the analysis and recommendations for further study.

CHAPTER II

BACKGROUND

This chapter presents the theory behind economies and diseconomies of scale as well as some relevant industrial examples. Following this, there will be a discussion of how an organization can use either its production function or cost function to determine if it is experiencing economies or diseconomies.

The theory of economies and diseconomies of scale and plant size was nearly the exclusive province of economic theorists until the late 1960s (1:25). Following its emergence in the industrial sector, it seemed as though all problems in the society could be solved by making everything larger. Thus, the phrase "bigger equals better" became a driving philosophy (1:26). In the mid 1970s, the industrial sector changed its philosophy and the phrase "small is beautiful" emerged (1:28). This change in philosophy resulted from the realization of the fact that the principle of economies of scale does not occur indefinitely. As the size of a plant and scale of operations increases beyond a certain point the principle of diseconomies takes effect. What causes either economies or diseconomies of scale to exist and how can an organization determine which one they

are experiencing? The remainder of this chapter attempts to answer this question.

Economies of Scale

Economies of scale and/or plant size is an economic principle which states that as the size of a plant and the scale of operations become larger the unit costs of production decrease (9:208). Adam Smith presented two primary reasons for the existence of economies in production operations: the specialization and division of labor and technological factors.

The specialization and division of labor results in economies because as the number of workers within a plant increases there is increased opportunity for the workers to specialize in a specific skill (9:209). This specialization results in improved task performance and minimum time loss due to the changing of tools (11:214). Specialization also results in increased production due to the learning curve effect (1:38): the learning curve effect is caused by the repetition of the same job over and over. As each job is repeated, the laborer builds experience and the effort required per unit of output decreases. This results in an increase in the output produced by each laborer.

Technological factors can result in economies because as a plant increases in size there is increased opportunity to properly integrate production equipment in

order to achieve maximum output thus eliminating idle time. For example, suppose there are two types of machines required to manufacture a product. The one type produces the product and the other packages it. If a producing machine can produce thirty thousand units per day and a packaging machine can package forty-five thousand units per day, a plant will have to use three producing and two packaging machines and manufacture ninety thousand units per day in order to fully utilize the capacity of the machines. Manufacturing less than ninety thousand units per day will result in either one type of machine or the other experiencing idle time (9:209).

Also, as a plant increases in size, larger machines are usually purchased and installed which result in economies.

> For example, a printing press that can run 200,000 papers per day does not cost 10 times as much as one that can run 20,000 per day--nor does it require 10 times as much building space, 10 times as many men to work it, and so forth [9:209].

This particular facet of technological economies is sometimes referred to as "economy of the big machine" (14:41).

Another facet of technological economies is the "two-thirds rule" (14:41). This rule is somewhat similar to the idea of "economy of the big machine". The principle behind the "two-thirds rule" is that the capacity of a container increases as the cube of its dimensions while the

material required to make it increases only as the square of its dimensions (14:41). For example, if there is a storage container in the shape of a cube that is ten feet wide, ten feet high, and ten feet deep, it will have a capacity of one thousand cubic feet and will require six hundred square feet of material to make. If the dimensions of the container are doubled (twenty feet wide, twenty feet high, and twenty feet deep), it will have a capacity of eight thousand cubic feet and require twenty-four hundred square feet of material to make. In other words, by doubling the size of the container the capacity has increased by a factor of eight while the material required to make it has only increased by a factor of four resulting in a lower cost per cubic foot of capacity.

Another theory regarding economies of scale, presented by Schmenner (13:100-104), states that scale economies can be divided into three different economies: economies of volume, economies of capacity, and economies of process technology.

Economies of volume result from a production facility producing a larger number of output units. This higher volume of production causes the fixed costs associated with the production facility to be allocated to a larger number of units and therefore unit costs are reduced. For example, if a production facility has fixed costs of one million dollars and produces 500,000 units of output, the fixed cost

per unit of output will be $2.00. However, if production is increased to one million units, the fixed cost per unit of output will be reduced to $1.00.

Economies of capacity are primarily due to a larger plant's ability to carry less inventory and have more spare equipment and maintenance capability. A larger capacity plant can carry less raw materials inventory "due to the familiar 'economic order quantity' result that optimal inventories need increase only as the square root of volume and not proportionately with the volume [13:101]." Also, the finished goods inventory of the larger plant will be proportionately lower than a smaller plant because the larger plant will have the production capability to engage in the output of more than one product at the same time. Whereas, the smaller plant would have to build up a sizeable inventory to satisfy the demand for a product while the plant changed its production operation around to produce a different product. Additionally, the larger capacity plant has more spare equipment available and maintenance capability than the smaller capacity plant. For instance, the larger plant will be able to sustain operations if a piece of equipment breaks by substituting a piece of idle equipment or opening an idle production line while the broken piece of equipment is repaired. A smaller plant with limited production capacity does not have this luxury.

Economies of process technology are due to increased automation and the specialization of labor. An automated plant substitutes capital for labor which usually results in lower labor costs and increased output. The specialization of labor creates economies because of increased productivity through repetition and specialized competence as previously discussed.

Although Schmenner divides economies of scale into three separate economies, the underlying reasons for economies of volume, capacity, and process technology relate to either specialization and division of labor or technological factors as described by Adam Smith.

One additional factor relative to economies of plant size is pecuniary economies (8:212). Pecuniary economies are a direct result of the absolute size of the firm. Larger firms are able to get discounts for bulk purchases of raw materials which translate into reduced costs for the production of an output. Also, larger firms operating more than one plant are able to spread under-utilized fixed cost expenditures such as managerial talent, computer rental, and advertising over a wider range of output. Once again, this translates into reduced costs for the production of a specified output.

Diseconomies of Scale

From the previous section, it appears that by getting larger and larger a production facility will continue to realize economies and produce its product at a decreasing cost indefinitely. However, there is a point in the size of a firm where diseconomies take effect. Simply stated, diseconomies occur when the increase in the size of plant and scale of operations results in increased cost per unit of output (11:216).

The main reasons for the occurrence of diseconomies are the limitations on managerial ability and the difficulty in getting accurate information to the decision makers.

> As the scale of plant expands beyond a certain point, top management necessarily has to delegate responsibility and authority to lower echelon employees. Contact with the daily routine of operation tends to be lost and efficiency of operation to decline. Red tape and paperwork expand; management is generally not as efficient [9:210].

Because different managers have different abilities and some organizations are more efficient at processing information than others, the point at which diseconomies take effect is often difficult to determine and varies from organization to organization. However, the fact remains that for all organizations engaged in production there is a point in size where diseconomies begin.

Determining the Existence of Economies or Diseconomies

Realizing the fact that all organizations engaged in the production of an output encounter either economies or diseconomies, the next logical step is to determine which one they are experiencing. To determine this, an organization can use either their production function or their cost function. Economies or diseconomies of scale are determined through increasing or decreasing returns to scale in a production analysis or the behavior of the long run average cost curve in a cost analysis.

Before examining the theory and mechanics of the production and cost functions, two other terms, "short run" and "long run", need to be defined. The short run refers to a period of time in which some of the inputs required for the production of an output are variable while other inputs are fixed. For example, variable inputs generally include labor and materials which vary with the output produced, and fixed inputs generally include the land, buildings, and machinery which do not vary with the output. The long run refers to that point in time where none of the inputs required for the production of an output are fixed (i.e., all inputs are variable). The fixed inputs in the short run (e.g., land, buildings, and machinery) could be changed to meet changing demands for the output. With these two terms

in mind, the discussion now turns to an organization's production function.

Production Analysis

In broad economic terms production in an organization can be defined

> ... as the transformation of resources into products, or the process whereby inputs are turned into outputs. The efficiency of this process usually depends upon the proportions in which the various inputs are employed, the absolute level of each input, and the productivity of each input at each input level and ratio. Since inputs are generally not free but have a cost attached, the degree of efficiency in production translates into a level of cost per unit of output [8:190].

The process whereby inputs are turned into outputs can be technically specified for each production facility through the use of a production function. In general mathematical form, the production function can be described as

$$Q = f(K,L) \tag{1}$$

where Q is the quantity of output, f represents the functional relationship existing between inputs and output, K represents the input level of capital, and L represents the input level of labor (8:191). In this particular relationship, K represents all inputs of capital (e.g., land, equipment, machinery) and L represents all inputs of labor (e.g., a worker's time, raw materials, fuel, and other variable inputs). From this general relationship, each organization

can express its own specific form of the functional relationship in a mathematical equation which best expresses the actual relationship between its inputs and outputs. This mathematical expression depends upon the state of technology faced by the organization or what is called the productivity of the input factors at various levels of all inputs (8:191). By substituting different values for labor (L) and capital (K) in the functional relationship the output quantity (Q) can be determined. The plotting of the different values of L and K and their associated Q results in a three-dimensional graph represented by Figure 1. This graph is called the output hill or production surface.

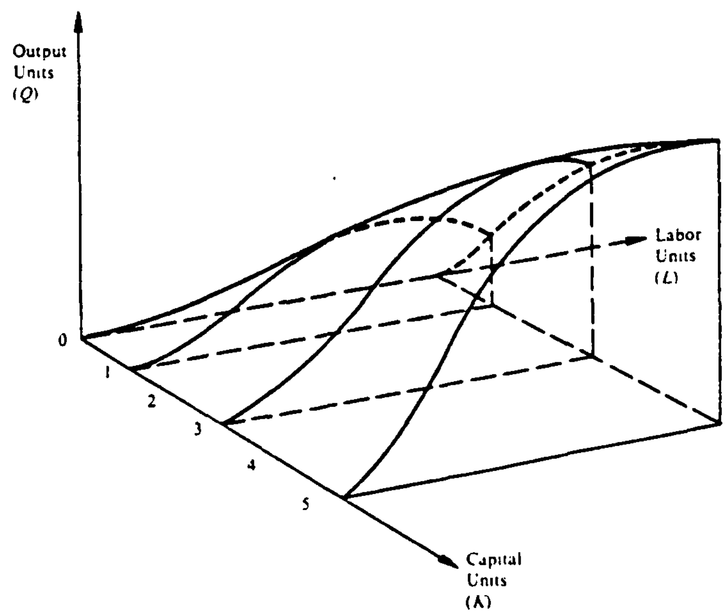

Fig. 1. Production Surface (8:193)

By slicing the graph of the output hill for a particular production function through different planes and observing the shapes of the resultant line formed by the production surface, a number of important concepts related to production can be demonstrated.

For instance, by slicing the graph for the output hill using a ray drawn from the origin along the base indicates a constant ratio of capital to labor (K/L) as shown in Figure 2.

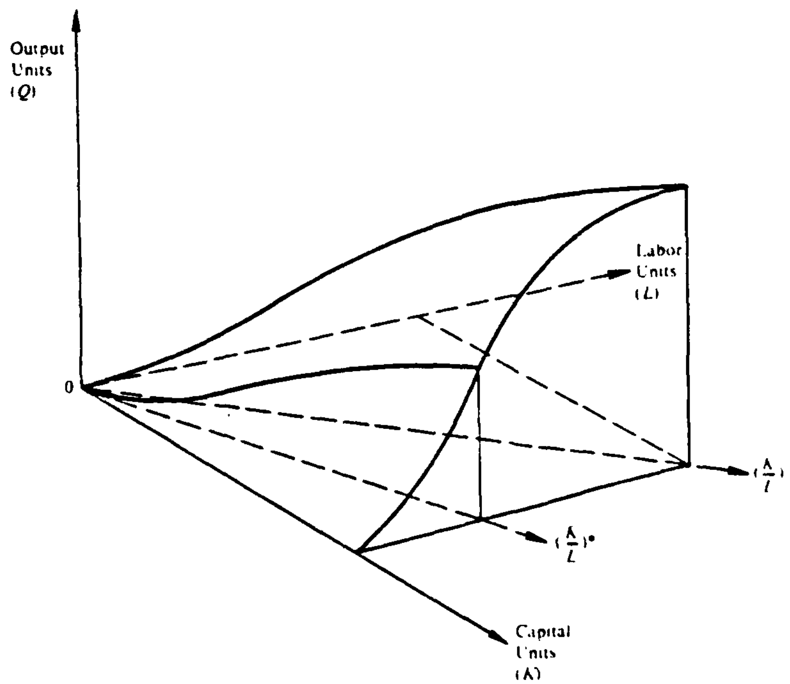

Fig. 2. Returns to Scale (8:197)

The top line of the plane formed can be used to determine an organization's returns to scale for a particular ratio of capital to labor (K/L). In other words, the ratio of (K/L) equals a constant and by increasing the units of capital (K) employed, the units of labor (L) will also increase to maintain the same value for (K/L). A two-dimensional plot of this plane forms a total product curve as shown in Figure 3.

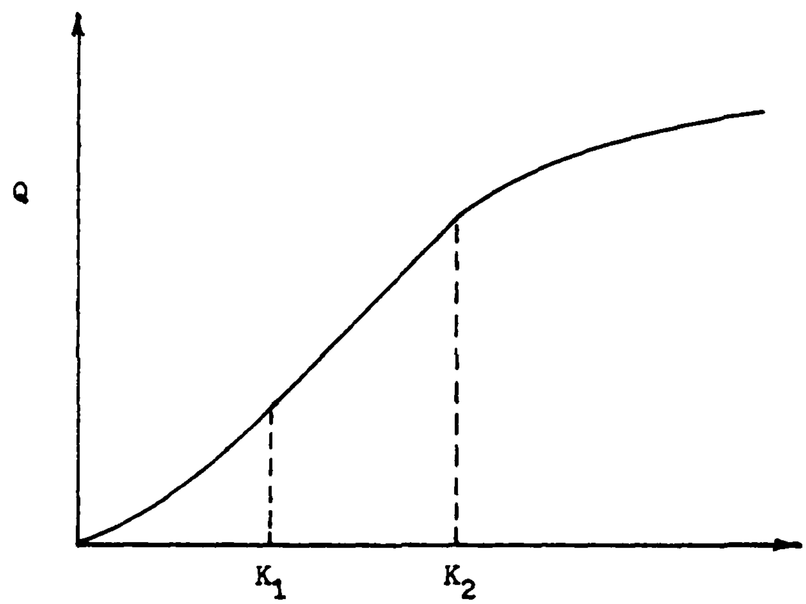

Fig. 3. Returns to Scale with Constant (K/L) Ratio

This curve indicates whether increasing the scale of operations (increased units of K employed) using a constant ratio of capital to labor will result in increasing, constant, or decreasing returns to scale. The production of an output using capital up to K_1 units results in increasing returns

to scale. Producing in the range K_1 to K_2 units of capital results in constant returns to scale, and producing in the range above K_2 units of capital results in decreasing returns to scale. Such a chart for various (K/L) ratios can be determined provided an organization's production function is known. Thus, an organization can determine whether it is producing in the range of increasing, constant, or decreasing returns to scale.

There is another method an organization can use to determine its returns to scale knowing its production function. If an organization increases its scale of operations while holding its factor proportion of capital to labor constant, it can determine whether its output occurs in an area of increasing, constant, or decreasing returns to scale by observing the percentage change in output as compared to the percentage change in inputs. If the percentage change in output is greater than the percentage change in input, the organization is experiencing increasing returns to scale. Similarly, if the observed percentage change in output is equal to the percentage change in input, the organization is experiencing constant returns to scale. Finally, if the percentage change in output is less than the percentage change in input, the organization is experiencing decreasing returns to scale.

Cost Analysis

Production efficiency can also be determined through a cost analysis as well as a production analysis. Since the inputs to production are not free, the input costs can be applied to all levels of factor inputs and the cost levels for all levels of output can be determined. Production and costs are thus intimately related. The first step in determining whether economies or diseconomies exist in an organization using the cost analysis technique is for the organization to determine its relevant cost relationships. These cost relationships are expressed as a function of the output produced or expressed mathematically

$$C = f(Q) \qquad (2)$$

where C represents either total costs in dollars or costs per unit of output in dollars per unit, f represents the functional relationship existing between costs and output, and Q is the quantity of output.

The primary cost relationship of interest to determine whether economies or diseconomies of scale exist is the long run average cost curve (LAC). This curve is determined by developing the envelope curve to an infinite number of short run average cost (SAC) curves.

To determine a SAC curve, a plant first has to determine its total variable cost (TVC) curve as a function of

the output produced. A TVC curve is derived from the total product curve by multiplying the level of variable inputs by the cost per unit of those inputs and plotting the resultant cost data against the output level. Since the TVC curve is derived directly from the total product (TP) curve, the TVC curve is related to the production function and the number of units of fixed factor employed in determining a particular TP curve. Once the TVC curve is determined, the average variable cost (AVC) curve can be constructed by dividing the total variable costs by the quantity of output produced at all output levels. By adding the total fixed costs (TFC) to the TVC at each level of output, the total cost (TC) curve is obtained. Once the total cost curve is determined, the SAC curve is constructed by dividing the total costs by the number of output units produced. Figure 4 shows the resultant AVC and SAC curves of a hypothetical production operation at a specific level of fixed factor inputs.

The decrease in the average cost per unit up to Q_1 units of output is caused by an increase in the marginal productivity of the variable factor inputs and a decrease in the allocable fixed costs for each additional unit of output. The increase in the average cost per unit at output levels above Q_1 is caused by the variable costs of production increasing at a faster rate than the allocable fixed costs per unit are decreasing.

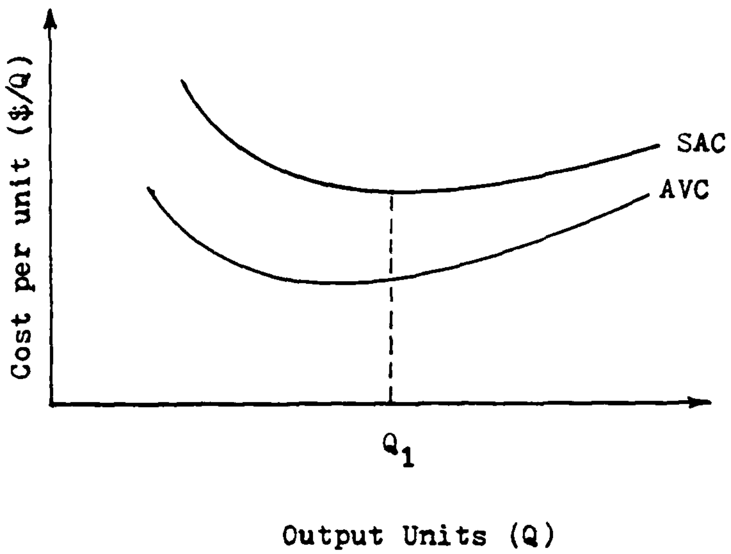

Fig. 4. Short Run Average Cost Curves

The same procedure is used to find the SAC curve that relates to every level of fixed factors. From each level of capital (fixed factor input) a total product curve can be determined, from which the TVC curve and ultimately the SAC curve is determined. Following this procedure for each level of fixed factor would result in a series of SAC curves, each with a larger level of capital input as the output level increases from a minimum to a maximum (8:208). There can be an infinite number of these SAC curves. The "envelope curve" formed by these SAC curves is the LAC curve as shown in Figure 5. This figure indicates that the LAC curve

> ... is made up of the points on the various SAC curves that allow each output level to be produced at

the lowest possible cost when the firm is free to vary the input of all resources [8:208].

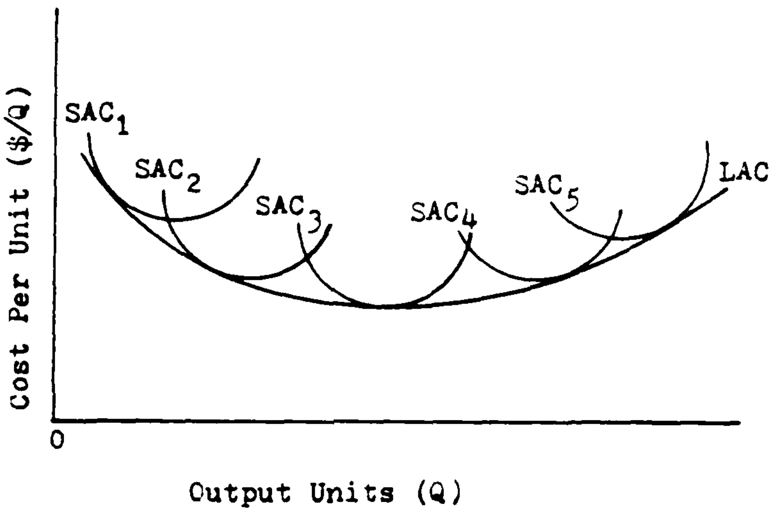

Fig. 5. Long Run Average Cost Curve

The LAC curve in Figure 5 also implies lower and lower average costs until the "optimum" scale of plant shown by SAC_3 is reached, and thereafter successively higher average costs as the plant size increases. This phenomenon of first decreasing and then increasing LAC values indicates the existence of economies and then diseconomies of scale. As discussed previously, economies occur because larger output plants can use more efficient capital intensive methods of production and allow for increased specialization and division of labor, and the diseconomies result from the

increasing bureaucracy and management problems associated with large scale plants.

At this point, it is important to point out that most organizations in the real world will not exhibit the perfectly formed curves for production and cost relationships that have been presented. In many instances the LAC curve is L-shaped. However, the theory is sound and empirical observations support the underlying theory (8:195). For example, a study done by Vinod K. Gupta of twenty-nine manufacturing industries showed that

> ... in 18 of the industries studied, the long run average cost curve is L-shaped, in 5 it is U-shaped and the remaining ones are linear. The observation that so many are L-shaped does not necessarily refute the theory of a U-shaped long run average cost. It may well be that the scale of output at which costs would turn up had not been reached [17:273].

Also, Wilson and Darr (17:273) stated that, "There is no large body of data which convincingly contradicts the hypothesis of a U-shaped long-run cost curve and the fruitful results which depend on it."

Thus, an organization can determine whether it is producing its output in a range where economies or diseconomies occur through either an analysis of its particular production function or cost relationships. Either method is acceptable because the cost relationships depend on the organization's underlying production function and vice

versa. Evan J. Douglas (8:213) sums up this interrelatedness as follows:

> The shape of the long-run average cost curve depends upon the various short-run average cost curves. The shapes of the short-run cost curves in turn depend on the total product curves. The shapes of the total product curves depend upon the production surface. This in turn depends on the specific or mathematical form of the production function. Thus the U-shaped short-run cost curves are the result of variable proportions, and the shape of the long-run average cost curve is due to economies and diseconomies of plant size. All of this is involved in the underlying production surface. Whenever we draw a particular set of cost curves, we therefore implicitly presume the shape of the underlying production surface. Similarly, whenever a production function is specified, the shape and position of the cost curves is simultaneously implied.

Summary

The first section of this chapter presented the economic theory of economies and diseconomies of scale. Economies and diseconomies of scale are primarily due to production efficiencies and inefficiencies caused by increasing and decreasing returns to the variable factors of production. Also, economies are caused by the specialization and division of labor and technological factors, and diseconomies are caused by limitations on managerial ability and information flow.

The next section discussed how an organization determines whether it is experiencing economies or diseconomies through either an analysis of its production function or cost relationships. The production function expresses

the relationship between the input factors of capital and labor to the output produced. Once an organization's production function is known, a graph of the production surface or output hill can be constructed. By slicing the production surface along a constant capital to labor ratio and plotting the resultant total product curve in a two-dimensional graph, an organization can determine whether it is experiencing increasing, constant, or decreasing returns to scale. Additionally, the production function itself (if known) can be used to determine whether increasing, constant, or decreasing returns to scale exist.

Economies and diseconomies can also be determined through the use of an organization's cost relationships which are directly related to the production function. Once the total variable cost curve is derived from an organization's total product curve, the average variable cost curve can be determined. By adding in the total fixed cost values for all levels of output, the short run average cost curve can be derived. The characteristic U-shape of this curve results from the increasing and decreasing average productivities associated with the variable factors of production and the decreasing average fixed costs as the level of output increases. The primary cost curve of interest for determining the existence of economies or diseconomies of scale is the long run average cost curve. This curve is

derived by developing the envelope curve that is just tangent to an infinite number of short run average cost curves for various sizes of plants at a particular point in time. Once the long run average cost curve is determined, the organization can determine whether its scale of plant is in the region of economies or diseconomies of scale.

The next chapter will use this theoretical background in developing the methodology used to determine whether economies or diseconomies exist in the undergraduate pilot training environment.

CHAPTER III

METHODOLOGY

This chapter presents the source data and method of analysis for studying whether economies or diseconomies exist in the production of undergraduate pilots. The first section discusses the methods an organization can use to determine its cost relationships based on empirical evidence. The next section discusses the type of data required for this study, where it was obtained, and how it was accumulated. The third section discusses how the total training costs were determined and the final section covers the computer methodology for applying the regression technique.

Determination of Cost Relationships

The previous chapter discussed how an organization engaged in production can determine whether economies or diseconomies exist using either the organization's production function or cost relationships. Cristensen and Green (3:658) found that the best way to study the structure of production in an organization depended upon whether the output level is determined internally or externally. They determined that if the output level is determined internally, then the best method for study was through the

organization's production function; and if the output level is determined externally, then the best method for study was through the cost relationships. Since this study examines the production of undergraduate pilots where the producing facilities receive their output quota externally, three methods for determining an organization's long run cost relationships will be discussed. The three methods presented by Douglas (8:254, 262-268) are the survivor principle, engineering technique, and regression analysis.

The survivor principle method, developed by George Stigler (15:54-71), is based on the assumption that the more efficient firms will tend to survive and increase their market share while the less efficient firms will tend to become less important as time passes. Stigler's procedure is

> ... to classify the firms in an industry into size classes and calculate the share of the total industry output coming from each class over time. If the share of a particular class declines over time, the inference is made that the size of the firm is relatively inefficient and is therefore smaller or larger than the optimal scale of plant [8:265].

The size categories that maintain or increase their market share over time are considered to be efficient and therefore likely to have lower per unit costs. There are certain problems that arise when using this method to infer the shape of the long run cost curve. For instance, a firm could suffer a decrease in market share for reasons other than production inefficiency such as poor management,

adverse publicity, or low labor productivity. If these reasons are systematically related to the size of a firm, the survivor principle would indicate a cost difference between different sized firms. On the other hand, these cost differences may be due to other problems of a temporary nature. However, if the data base is sufficiently large, the influence of these random or temporary factors should cancel and a clear tendency can be ascertained as to whether the market shares are increasing, constant, or decreasing for a particular sized firm.

The engineering technique for the determination of long run average cost is an extension of the engineering technique used to determine the short run costs. This method consists of developing the physical production function between the inputs and outputs of a production process for a particular plant size and attaching the cost values to the inputs in order to obtain the total variable costs for each output level. From the total variable costs the average variable costs can be determined. The average fixed costs for each level of output are added to the average variable costs to obtain the short run average costs (SAC) for a particular size of plant. The same technique would be used to determine the short run average costs for various plant sizes at different output levels. Plotting the results on a graph of "cost per unit" versus "level of

output" would result in a graph similar to Figure 6 where the asterisks (*) represent the different values at different outputs for the various size plants represented by SAC_1, SAC_2, etc.

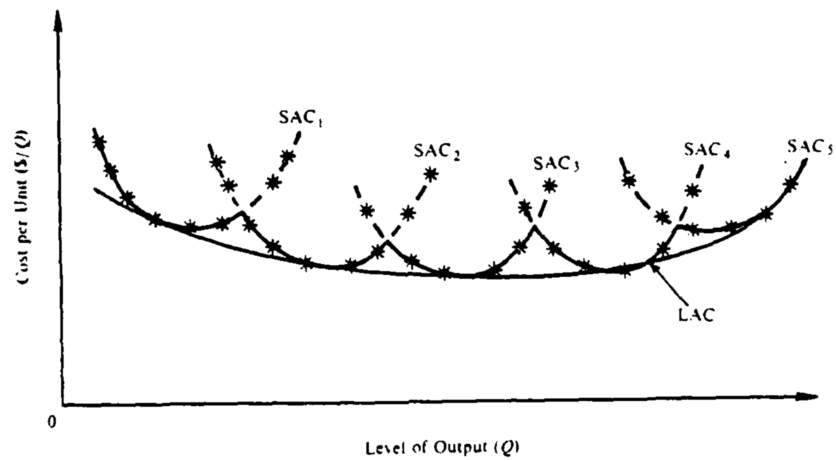

Fig. 6. LAC By Engineering Technique (8:267)

The long run average cost (LAC) curve is then determined by drawing the envelope curve which is tangent to all of the short run average cost curves. The problem with this method is that it is slow and tedious because the input relationships and factor prices must be determined through testing and observation. Also, the long run average cost curve determined by this method is predicated upon the fact that factor productivity and factor prices are at similar levels in each of the available plant sizes. Additionally, the factor prices and productivities depicted by this analysis

are applicable only as long as the variables do not change. If these variables change, then new short run average cost curves and the resultant long run average cost curve must be determined.

The final method for determining the average cost relationships is regression analysis. Regression analysis can be performed on either a cross-section or time-series basis. The cross-section method uses cost/output observations from various plants at a particular point in time (cross-section data), and the time-series method uses cost/ output observations from the same plant over a number of time periods (time-series data). The regression analysis method is probably the most widely used because it is easy to apply through the use of established computer programs (17:268).

There are three problems associated with the cross-section method. First of all, care must be taken to avoid errors of measurement relating the actual level of output to the total costs associated with producing that output. Secondly, the observations collected may not be points on the long run average cost curve at all. For instance, suppose there are five plants with the short run average cost curves (AC_1, AC_2, AC_3, etc.) depicted in Figure 7. The asterisks (*) indicate the observed output average cost pair for each of the five plants. Using the regression technique would

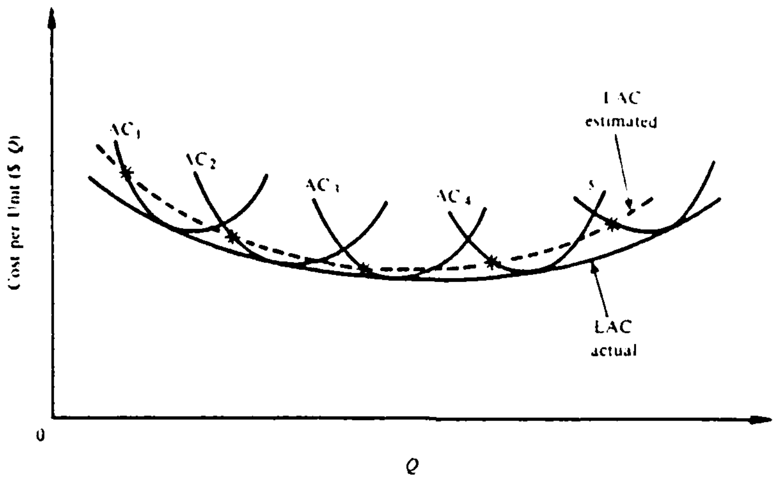

Fig. 7. LAC By Cross-Section Regression (8:265)

result in the estimated LAC curve depicted in Figure 7. The figure indicates that the estimated LAC curve is different from the actual LAC curve because the observed points were not at the point of tangency between the AC curves and the actual LAC curve. Since each firm will probably not be operating at this point of tangency, the regression analysis technique of cross-section data is likely to produce a slightly misleading picture of the actual economies and/or diseconomies of plant size (8:263). Thirdly, the various plants may not be operating with the benefit of the same factor prices and/or factor productivities. This is primarily due to the plants operating in different geographical, political, and socioeconomic environments. If these differences are not removed from the data, the resultant LAC

curve may obscure the existence of economies and/or diseconomies.

There are two problems associated with the time-series method. First of all, because this method uses time-series data (data collected over a number of time periods), it is subject to the standard problems of such data such as changing factor prices due to inflation or market forces, and changing factor productivities due to changing technology and worker efficiency. Secondly, the time-series method is subject to the problems of measurement error such as matching all costs associated with the production of a certain output. To minimize the measurement error, the cost/output observations should satisfy the following conditions (10:26):

1. The basic time period for each pair of observations should be one where the output is achieved by a uniform rate of production within the time period.

2. The cost and output figures should be properly paired (cost figure directly associated with output figure).

3. There should be a wide spread of output observations so that cost behavior could be observed at different output rates.

4. The data should be uncontaminated by the influence of factors extraneous to the cost/output relationship. In reality, the best source of information for analysis

would be the records of organizations over successive time periods during which their capacity remained constant (10:28).

This study will use the regression analysis method to determine the appropriate average cost relationships because it gives the best estimates of the functional relationships that exist between output and costs based on a set of empirical observations. Also, the availability of standard computer programs will minimize the human effort that would otherwise be involved.

Additionally, the regression analysis method will be used because it provides some valuable information. First of all, the regression equations will show the explicit relationships between average cost and pilot output. According to Wilson and Darr (17:91) an explicit model has the following advantages:

1. The user is able to formulate and quantitatively account for complex relationships that exist between variables.

2. The user is able to measure the separate quantitative effects of each independent variable on the dependent variable.

3. The user can test the validity of the relationship to determine which independent variables are significant.

4. The user can derive different measures of probable error.

Secondly, the regression analysis will show how good the regression equation is by providing statistics of reliability. In other words, how much of the variation in average cost is explained by the variation in output.

Source of Data

This thesis required data which related pilot output with their associated costs. In other words, a series of cost/output observations were required for the different bases engaged in pilot production over a specific time period and for the individual bases over a number of time periods. The time period chosen for cross-section analysis was the fiscal year (FY) because both the cost and output data were accumulated and reported over this period. For the time-series analysis, data was accumulated for FY 68 through FY 79. All data was obtained at Headquarters Air Training Command (ATC) located at Randolph Air Force Base, Texas. The data on pilot training costs was obtained through records maintained by the Cost and Management Analysis Directorate, and the data on pilot output production was obtained through records maintained in the Directorate of Operations Plans. Because pilot production figures are straightforward and not subject to different interpretations, they require no further explanation. However, the

cost figures are subject to different interpretations and measurement problems and therefore require an explanation of the relevant costs involved and accumulation procedures used.

Relevant Costs

The relevant costs for this study can be broken down into five major elements: flying, direct, indirect, student, and command support.

Elements included in flying costs are depot maintenance, replenishment spares, aviation fuel, and flight clothing. The depot maintenance, replenishment spares, and aviation fuel costs are determined by an allocation procedure based on factors assigned by Air Force Headquarters. This results in a standard cost for these resources throughout ATC and the Air Force.

Direct costs include the operating costs of units and activities directly involved in the conduct of the training program. Normally, the training group and direct support activities such as the weather detachment and air traffic control communications are included in this element. This element is further broken down into military pay, civilian pay, purchased services, materials and other operation and maintenance costs such as utilities, staff TDY, communications, etc.

Indirect costs include the operating costs of all other base units and activities engaged in indirect support of the training program. Normally, this is the cost of all other base activities not included in direct cost except where the base also supports a non-training mission. In the instance of multi-missions, the cost of support activities is allocated to the missions on the basis of relative magnitude. Once again the indirect costs are broken down into military pay, civilian pay, purchased services, materials, and other operation and maintenance costs.

Student costs include student pay and allowances and expenses incurred for temporary duty assignments. The pay and allowances are computed using the modal grade of the students located at a base as shown in the Formal Training Course Cost Report and the application of a standard military pay factor.

Command support costs include an allocation to each base of a proportionate share of the operating cost of Headquarters ATC and the support of the headquarters by Randolph AFB.

System Used to Accumulate Costs

The accumulation and breakdown of these relevant costs is an involved process. The Cost and Management Analysis Directorate (CMAD) at Headquarters ATC receives the raw cost figures and operational statistics from two main

sources. One source is the Accounting System for Operations which accumulates costs based on Operating Budget Account Numbers (OBAN). The OBAN breaks the costs down by base, program element, cost center, and military and civilian pay. The other major source is individual reports submitted by each base directly to CMAD. These reports include the costs associated with the tenant units located at a particular base plus other information such as flying hours, student load, attrition rates, assigned personnel, etc. The CMAD analyzes this data and breaks the costs down for each base into either training or non-training related. The training costs are then directly assigned to the various training courses conducted at a certain base if possible. If direct assignment is impossible, the costs are allocated among the various courses according to the most appropriate method available. At this point, the costs and operational statistics are computerized and put into the Formal Training Cost Reports program (RCS: HAF-ACM(AR)7108). This program produces several output products, one of which (AF Form 611) breaks the training costs down by base and training phase (preflight, T-37, T-38). Within each phase, the costs are broken down into flying, direct, indirect, student, and command support, and reported on a dollars per student week basis. This report was the major source of cost figures used in this study.

Determination of Training Costs

The total costs per fiscal year per base were computed by summing the total costs per student week for each phase and multiplying this figure by the student weeks of training involved in that phase. The total cost figures for each phase were then added to obtain the total costs for a particular base for a fiscal year (FY). This procedure was accomplished for all bases involved in pilot production from FY 68 through FY 79. The resultant total costs along with the number of graduate pilots produced for each base are listed in Appendix A. Data for years prior to FY 68 was not accumulated due to a scarcity of reliable cost figures and the numerous changes in the cost accounting procedures which would have made a meaningful study improbable. In fact, the data collected for FY 68 through FY 79 must be grouped and adjusted in order to remove the influence of technological and factor input price changes. Certain observations from the grouped data will need to be excluded for the same reasons. By removing these influences, the collected data will closely approach the ideal conditions for cost/output observations previously mentioned and enhance the results of the regression analysis.

Computer Methodology

Since the regression technique will be used to analyze the relationship of average cost to graduate pilots

produced, it is important to review the statistical assumptions associated with this technique. The statistical assumptions specified by Wilson and Darr (17:93, 107) applicable to this study are the following:

1. Average cost is linearly dependent on pilot output.

2. For each value of graduate pilot output there is a normal probability distribution of average cost values.

3. The mean value of average cost for each value of graduate pilots falls on the regression line.

4. Individual values of average cost may lie above or below the regression line by some amount called the error term. These error terms are normally distributed independent random variables.

5. The variances of the average cost distributions for each value of output are equal.

6. The number of data points is greater than the number of variables.

This study will apply a regression program for both a cross-section and time-series analysis of the empirical observations. The cross-section program will be applied to the average cost/graduate pilot observations for all bases during a particular year for each year of the study. The time-series program will be applied to the average cost/graduate pilot observations for each base over the number of

years studied. It will also be applied to the aggregate average cost/total graduate pilot observations for each year over the study's inclusive years.

The Statistical Package for the Social Sciences (SPSS) multiple regression subprogram, titled "REGRESSION", is the computer program selected for this analysis. This program was chosen because it provides for considerable control over the inclusion of independent variables in the equation, and because the variable transformation features allow for a regression analysis on functional forms other than a plain linear relationship. Also, the stepwise inclusion feature enables the development of a regression equation that yields predictions with a minimum number of independent variables.

Summary

This chapter initially discussed three methods an organization can use to determine its long run cost relationships: survivor, engineering, and regression. The regression method was chosen for this study because it will give the best estimates of the functional relationships that exist between average cost and the number of graduate pilots produced.

The next section discussed the type of data required for this study and where it was obtained. The data on training costs and number of graduate pilots produced was

obtained from Headquarters Air Training Command. The relevant costs involved in the training of a pilot were grouped into five major areas: flying, direct, indirect, student, and command support. This study obtained its cost data based on these five groups from the AF Form 611 computer product from the Formal Training Cost Reports computer program.

The third section explained the method used to determine the total training costs for each base for each fiscal year. The total training costs were only determined for FY 68 through FY 79 because reliable cost data was either scarce or not available prior to FY 68. To improve the cost data for a meaningful regression analysis, the data will have to be grouped, adjusted and some observations excluded.

The final section discussed the computer methodology that will be used to analyze the data. The SPSS program for multiple regression will be used to determine the functional relationship between average cost and graduate pilots produced. The program selected will be applied to both the cross-sectional and time-series data.

The next chapter will discuss the data and computer analysis as well as present the results of both the cross-sectional and time-series analyses. The final section will compare the results with the study's two hypotheses.

CHAPTER IV

ANALYSIS AND RESULTS

This chapter analyzes the collected data and presents the results of the analysis. The regression analysis section presents the specific models that were evaluated and the methods used to check for the goodness of fit and level of significance for each model. Following the analysis section, the specific results of the regression analysis on both the cross-sectional and time-series observations are presented and discussed. The results are then compared to the study's two hypotheses:

1. Economies of scale exist in the undergraduate pilot training environment.

2. The consolidation of pilot training operations results in decreased unit costs for the output produced.

Data Analysis

Grouping of Data

During the period chosen for study, the pilot training operation underwent several program changes which altered the number of aircraft flying hours that each student received. Thus, the total costs to train a pilot were influenced by the number of flying hours in the training

program. From FY 68 through FY 70, the program included 240 hours of flying which included thirty T-41 hours, ninety T-37 hours, and 120 T-38 hours. During FY 71 and FY 72, the combined T-37 and T-38 flying hours were reduced from 210 to 192.5 hours. Starting in FY 73, the combined T-37 and T-38 flying hours were increased back to the FY 70 level of 210 hours, and the T-41 training program was removed from the individual bases and centralized at a civilian field in San Antonio, Texas. The training program remained at the 210 flying hour level until the Instrument Flight Simulator (IFS) became operational in 1977. The program then changed to 175.4 hours combined T-37 and T-38 flying time plus 66.3 hours in the IFS. The combined total amounted to 241.7 hours. This new program was operationalized at one base in FY 77, two more bases in FY 78, and one base in FY 79. By the end of FY 79, Columbus AFB was the only base not under the IFS training program.

To examine the study's two hypotheses, it was necessary to group the data in order to remove the changes in the average cost of a pilot caused by the influences of different flying hour programs. The training programs were divided into the four groups shown in Table 1 based upon the number of flying hours each student received. The training programs for groups I and III are similar. The only difference between the two is that the group I training program

TABLE 1

TRAINING PROGRAM GROUPS

Group	FYs	Flying Hours
I	68-70	240
II	71, 72	192.5
III	73-79	210
IV	77-79	174.5 (IPS bases only)

includes the T-41 phase and the group III training program does not. Excluding the T-41 phase from group I will make it the same as group III. The dissimilarity between groups II and IV and the other groups makes their adjustment impossible. Therefore, this study will concentrate on the individual bases and fiscal years included in the groups I and III training programs. By doing this, 29 percent of the data points were excluded from the analysis. Groups I and III are broken down as shown in Table 2.

Adjustments

There are two adjustments necessary to the selected groups to prepare the cost figures for application of the regression technique.

First, the cost figures need to be adjusted for the rising cost of factor inputs due to inflation. The ideal way to account for these rising costs would be to apply a

TABLE 2

BASES AND FISCAL YEARS INCLUDED IN GROUPS I AND III

Base	Group I (FYs)	Group III (FYs)
Columbus	Not Open	73-79
Craig	68-70	73-77
Laredo	68-70	73
Laughlin	68-70	73-78
Moody	68-70	73-75
Randolph	68-70	Closed in FY 72
Reese	68-70	73-76
Vance	68-70	73-77
Webb	68-70	73-76
Williams	68-70	73-77

price deflator to each factor input such as fuel, civilian pay, spare parts, etc., at each base. This would allow the costs associated with each base over the number of years studied to be compared on an equal basis. Such an adjustment would remove the differences in the cost figures due to a base's geographical location and the varying rates of cost increases for each input factor. However, due to the accumulation procedure used to collect the training costs, this type of adjustment could not be made. To account for the changes in input factor prices an overall price deflator was applied to the total cost figures. The price deflator

chosen was taken from the <u>1980 Economic Report of the President</u> and dealt with the federal government's purchase of goods and services. Table 3 lists the price deflator for each year using 1972 as the base year.

TABLE 3 (29:207)

PRICE DEFLATORS

Fiscal Year	Adjustment Factor
68	.764
69	.800
70	.864
73	1.058
74	1.159
75	1.275
76	1.346
77	1.436
78	1.548
79	1.676

Secondly, the cost figures associated with the group I training program were adjusted to exclude the T-41 phase of training. Because the cost figures associated with this group were not broken down into the different training phases (preflight, T-41, T-37, T-38) an estimate had to be made of the percentage of total costs attributable to the

T-41 phase. An estimate of this percentage was computed using FY 73 cost data as a basis. FY 73 was chosen because the training program was the same and because the total training costs included the T-41 phase. Also, the total costs were broken down by phase which made it possible to determine the percentage of total costs caused by T-41 training. Table 4 presents a summary of the costs and percentages by base.

TABLE 4

T-41 TRAINING COSTS AS A PERCENT OF TOTAL FOR FY 73

Base	Total Cost	T-41 Cost	Percent
Columbus	41,601,433	1,567,796	3.8
Craig	35,495,194	1,107,226	3.1
Laughlin	38,191,111	1,467,517	3.8
Reese	40,307,168	1,521,159	3.8
Vance	31,929,441	1,449,863	4.5
Williams	46,210,646	1,656,989	3.6
Laredo	40,745,706	1,397,018	3.4
Moody	40,488,844	1,353,156	3.3
Webb	37,089,163	1,408,664	3.8

In FY 73, the T-41 training costs averaged 3.68 percent of the total cost. The 3.68 percent adjustment factor was

applied to the total costs for each base involved with the group I training program.

Exclusions

An additional action taken to minimize the influences of program and factor input price changes was to exclude the Vance AFB observations from the cross-sectional analysis and some of the Webb AFB observations from both the cross-sectional and time-series analysis.

The average cost/graduate pilot observations from Vance AFB were excluded because Vance depends on contractual arrangements for completion of many of the base's normal operating functions such as aircraft maintenance and civil engineering. This results in different input factor prices and productivities when compared to the other pilot training bases that depend on military personnel to perform the same functions.

The data from Webb AFB from FY 74 through FY 76 was excluded from the cross-sectional analysis because of its erratic behavior. Also, the observation from FY 74 was excluded from the time-series analysis because of its large deviation when compared to the other observations. The exact reasons for this erratic behavior could not be found, but it was probably caused by Webb's phasing in and out of special training programs such as fixed wing qualification training, security assistance training, and pilot instructor

training for the Vietnamese Air Force. This phasing in and out of special training programs probably resulted in enormous problems in deciding the proper procedures for allocation of training costs. This erratic behavior made these few observations unreliable, and therefore they were excluded from the analysis to prevent distorted results.

The grouping and adjustment of the data and exclusion of some of the observations minimizes the influence of program and input factor price changes as much as possible with the information available. This should result in a more meaningful comparison of average costs for pilot production between the various bases over the years studied. A summary of the adjusted costs, graduate pilots, and average cost per graduate pilot by base for each fiscal year is included in Appendix B.

Regression Analysis

This section discusses the regression technique used to analyze the empirical cost/output observations selected for study. Also, the functional models tested to explain the relationship between average cost and graduate pilots produced will be presented. Lastly, the statistic used to test the model for significance and the methods used to test the model for the goodness of fit to the empirical observations will be reviewed.

Models

Four specific relationships between average cost and graduate pilot production were selected for evaluation by the regression technique.

The first model tested was a straight linear relationship,

$$COST = A + B(GRADS) \qquad (3)$$

where COST is average cost, GRADS is graduate pilots, A is the constant, and B is the coefficient relating GRADS to COST.

The second model tested was a quadratic relationship between average cost and graduate pilots,

$$COST = A + B(GRADS) + C(GRADSSQ) \qquad (4)$$

where COST, GRADS, A, and B are interpreted as in the first model. GRADSSQ is the number of graduate pilots squared, and C is the coefficient of GRADSSQ. In this model, the independent variables were entered into the equation in a stepwise manner. In other words, the computer program chose the independent variable which had the greatest effect on average cost and entered it into the equation first. The computer program then took the independent variable which had the next greatest effect on average cost and entered it into the equation second. If the addition of the second

variable explained less than one-tenth percent of the variation in COST, the computer program would not include the second variable in the final expression. By doing this, the computer yielded an equation which predicted with a minimum number of variables.

The third model tested was a logarithmic relationship,

$$COST = e^{[A + B(GRADS)]} \quad (5)$$

where COST, GRADS, A and B are the same as before; (e) is approximately equal to 2.718; and the term, A + B(GRADS), is the exponent of (e).

The final model tested checked for a power relationship between average cost and graduate pilots,

$$COST = A(GRADS)^B \quad (6)$$

where COST and GRADS are interpreted as before, A is the coefficient of GRADS and B the exponent. A logarithmic transformation was made on this relationship to put it into a form suitable for computer analysis,

$$Ln(COST) = Ln(A) + B\ Ln(GRADS) \quad (7)$$

where GRADS, A, and B are interpreted as before. Ln(GRADS) and Ln(COST) represent the natural logarithms of graduate pilots and average cost respectively.

Statistics Used

The adjusted coefficient of determination is used to determine which model provides the best fitting relationship between average cost and graduate pilots on each set of data, and the F-test is used to check the overall level of significance of the regression equation.

In the multiple regression technique, the coefficient of determination measures the strength of association between a dependent and one or more independent variables. It simply measures the ratio of variation in the dependent variable explained by the regression equation to the total variation in the dependent variable. This study uses the adjusted coefficient of determination because it is a better estimator of the percent variation in the dependent variable explained by the independent variables. The adjusted coefficient of determination is the coefficient of determination adjusted for the number of independent variables in the equation and the number of observations involved. This makes it a better predictor of the variation in average costs caused by the variation in the independent variables (GRADS and GRADSSQ). Therefore, the model that explains the most variation in average cost based on graduate pilots produced has the largest value for the adjusted coefficient of determination.

The F-test is used to determine the overall significance of the regression equation to the observed data. Like the adjusted R-squared statistic, the F-test considers the number of independent variables in the equation and the number of observations involved. The computer determines an overall F-test value for the regression equation along with its associated significance level for each model tested. The model that has the largest F-test value and lowest significance level is the best model for explaining the relationship between average cost and the number of graduate pilots produced.

Results

This section of the chapter presents and describes the results of the analysis for the four regression models evaluated. The results of the cross-sectional analysis for the fiscal years under study will be presented first followed by the results of the time-series analysis on each base and pilot training in the aggregate. The final section discusses these results in comparison to the study's two hypotheses.

Cross-Sectional Analysis

The cross-section analysis used the regression technique on cross-sectional data to determine the long run average cost relationship for each fiscal year under study.

The results of the four models tested (linear, quadradic, logarithmic, and power) to determine the best fitting model for the average cost/graduate pilot observations are listed in Table 5. The adjusted coefficient of determination (aR^2), F-test value (F), and level of significance (α) are presented for each model for each fiscal year studied. In the case of a regression equation, the level of significance (α) is the probability of rejecting the null hypothesis that there is no significant relationship between the independent variables and the dependent variable when in fact the null hypothesis is true. Therefore, the lower the value for (α), the greater will be the weight of evidence favoring the alternative hypothesis that there is a significant relationship between the independent and dependent variables. An α of .00 in Table 5 and the remaining tables of this analysis indicate a significance level of less than .01.

A cross-sectional analysis was not made for FY 78 because of the shortage of compatible observations due to different training programs at the different bases. In FY 78 there were five bases producing undergraduate pilots; two of the bases were in the group III training program and three of the bases were in the group IV training program (see Table 1).

Also, the FY 79 cross-sectional analysis includes only those bases involved in the group IV training program

TABLE 5

CROSS-SECTIONAL RESULTS FOR EACH FISCAL YEAR

FY	Linear			Quadradic			Logarithmic			Power		
	aR^2	F	α	aR^2	F	α	aR^2	F	α	aR^2	F	α
68	.92	81.17	.00	.99	534.76	.00	.93	90.63	.00	.98	328.74	.00
69	.87	48.25	.00	.89	29.28	.00	.87	48.16	.00	.89	56.98	.00
70	.06	1.47	.27	.54	5.06	.06	.08	1.60	.25	.03	1.25	.31
73	.55	9.59	.02	.61	6.46	.04	.60	11.64	.01	.64	13.54	.01
74	.82	23.22	.01	.92	28.86	.01	.80	20.54	.01	.84	27.03	.01
75	.64	9.73	.04	.65	5.70	.10	.66	10.57	.03	.68	11.78	.03
76	.31	2.82	.19	.23	1.60	.39	.29	2.64	.20	.34	3.01	.18
77	0	.12	.76	0	.14	.75	0	.12	.76	0	.11	.77
79	.83	15.31	.06	--	--	--	.80	13.21	.07	.82	14.27	.06

because four out of the five bases producing undergraduate pilots were in the group IV category.

The model with the largest adjusted coefficient of determination (aR^2) and F-test (F) value is the model which best fits the data observations. Using the aR^2 value and F statistic, the four models can be rank ordered according to their goodness of fit for each fiscal year. The number of times each model provided the "BEST" to the "WORST" fitting relationship is shown in Table 6. Fiscal year 1977 was excluded from this table because the aR^2 value and F statistic indicated that none of the models tested explained the

relationship between average cost and the number of graduate pilots produced.

TABLE 6

RANK ORDERING OF FOUR MODELS FOR GOODNESS OF FIT FOR EIGHT CROSS-SECTIONAL ANALYSES

Model	Goodness of Fit			
	BEST	2d BEST	3rd BEST	WORST
Linear	1	1	4	2
Quadradic	3	1	1	3
Logarithmic	0	3	3	2
Power	4	3	0	1

Table 6 shows that the power model provides the best fitting relationship between average cost and graduate pilots produced on four occasions and the second best fitting relationship on three occasions. In other words, the power model provides either the best fitting or second best fitting relationship in 87.5 percent of the cross-sectional analyses. For this reason, the power model was chosen as the best indicator of the functional relationship between average cost and graduate pilots produced for the cross-sectional data considered. As a review, the general form of the model is

$$COST = A(GRADS)^{B} \qquad (8)$$

where COST is average cost per graduate, GRADS is the number of graduate pilots produced, A is a coefficient, and B is an exponent. Table 7 presents a summary of the coefficients (A), exponents (B), and values for aR^2, F, and α for the power function associated with each fiscal year of cross-sectional data.

TABLE 7

SUMMARY OF THE POWER MODEL FOR EACH FY OF CROSS-SECTIONAL DATA

FY	Coefficient A	Exponent B	aR^2	F	α
68	2,634,002	-.5505	.98	328.74	.00
69	1,455,577	-.4471	.89	56.98	.00
70	315,256	-.2135	.03	1.25	.31
73	3,499,382	-.6037	.64	13.54	.01
74	6,361,215	-.6633	.84	27.03	.01
75	1,374,005	-.3965	.68	11.78	.03
76	2,813,669	-.5309	.34	3.01	.18
79	540,364	-.2532	.82	14.27	.06

In addition to the aR^2 and F values, the significance level (α) is an indicator of the confidence that can be placed in the predictive ability of a regression model. The smaller the level of significance for a model, the more confidence can be placed in that model. For example, if one

model has an α of .01 and another model has an α of .05, more confidence can be placed in the predictive ability of the model with the α of .01. In statistical analysis, two levels of significance commonly used to express confidence in a statistical result are α equal to .05 or α equal to .10, that is a 95 percent or 90 percent confidence level. Using these two levels of significance, Table 7 indicates that the power model had a significance level of .05 or better in five out of the eight years or 62.5 percent of the time, and a significance level of .10 or better in six out of the eight years or 75 percent of the time.

In FY 76 and FY 70 the power model had a significance level greater than .10. Although the model exceeded this significance level in FY 76, it was still the best fitting model of the four tested. Fiscal year 1970 was the one year out of the eight cross-sectional analyses where the power model did not provide either the best or second best fitting relationship to the data.

Another important observation from Table 7 is that the exponent (B) of the power function has a negative value for each fiscal year. This indicates that in all cases there is an inverse relationship between average cost and graduate pilots produced. To further illustrate this point, Figures 8, 9, and 10 are graphical representations of the functional relationships for each cross-sectional analysis.

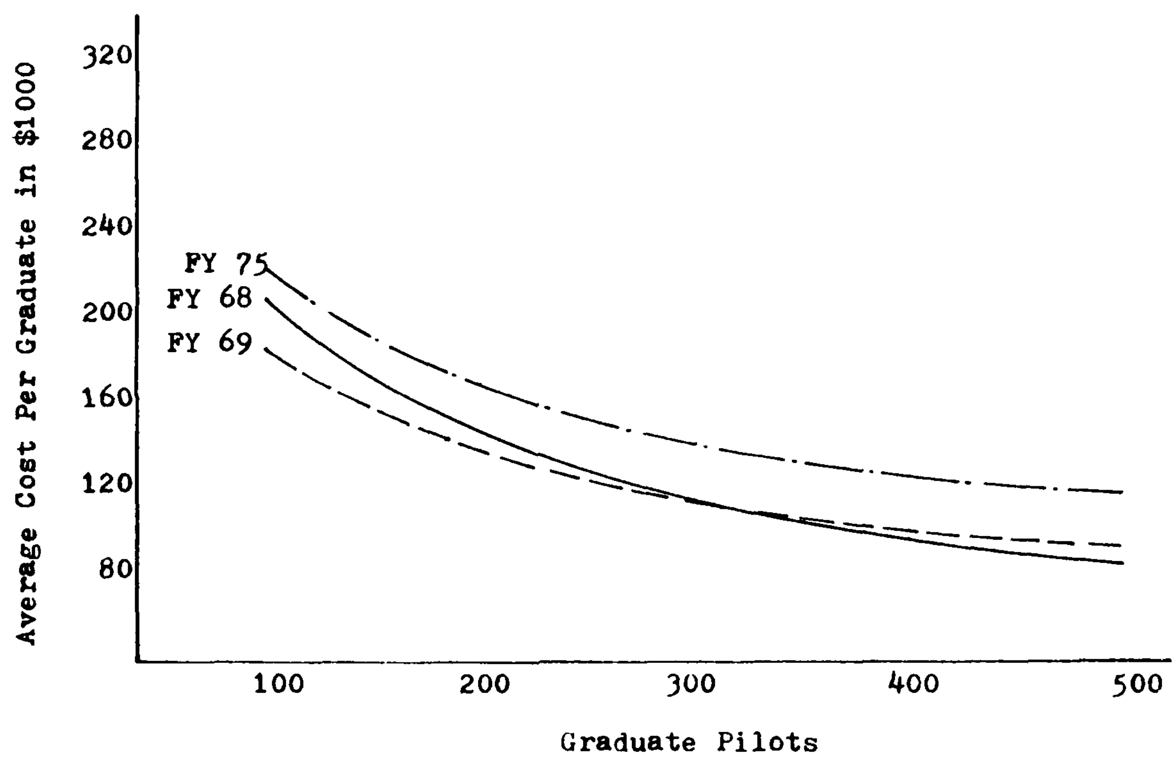

Fig. 8. Cross-Sectional Analysis

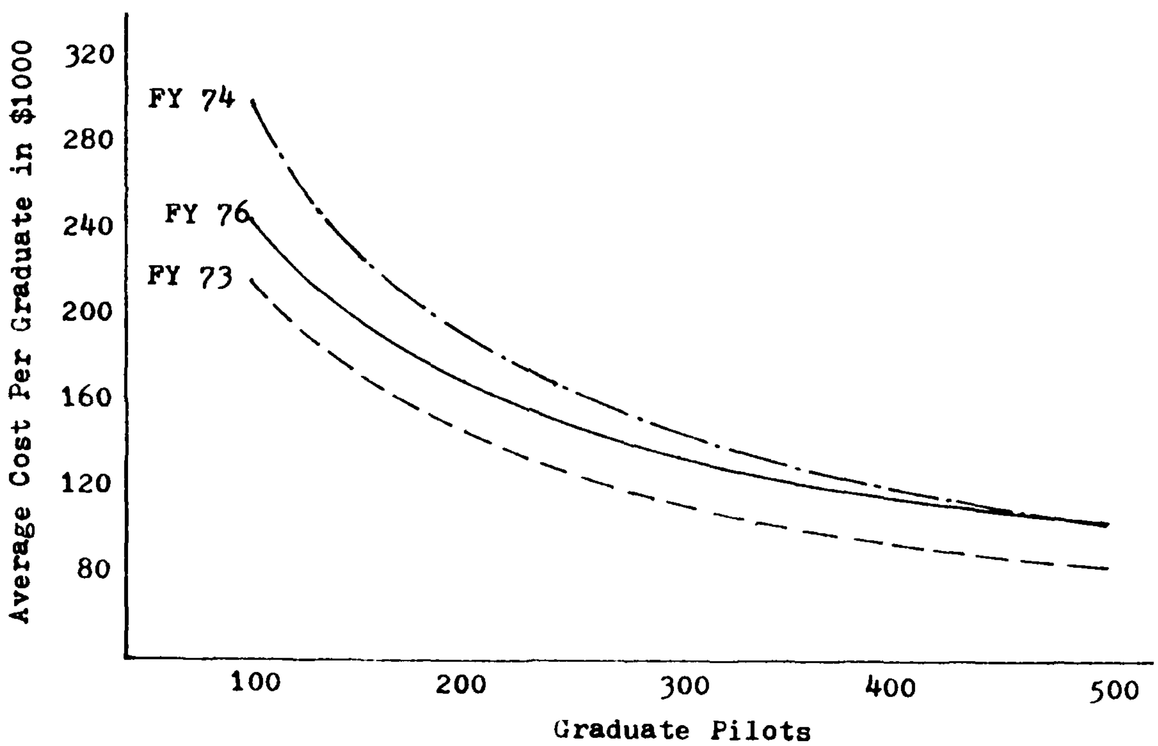

Fig. 9. Cross-Sectional Analysis

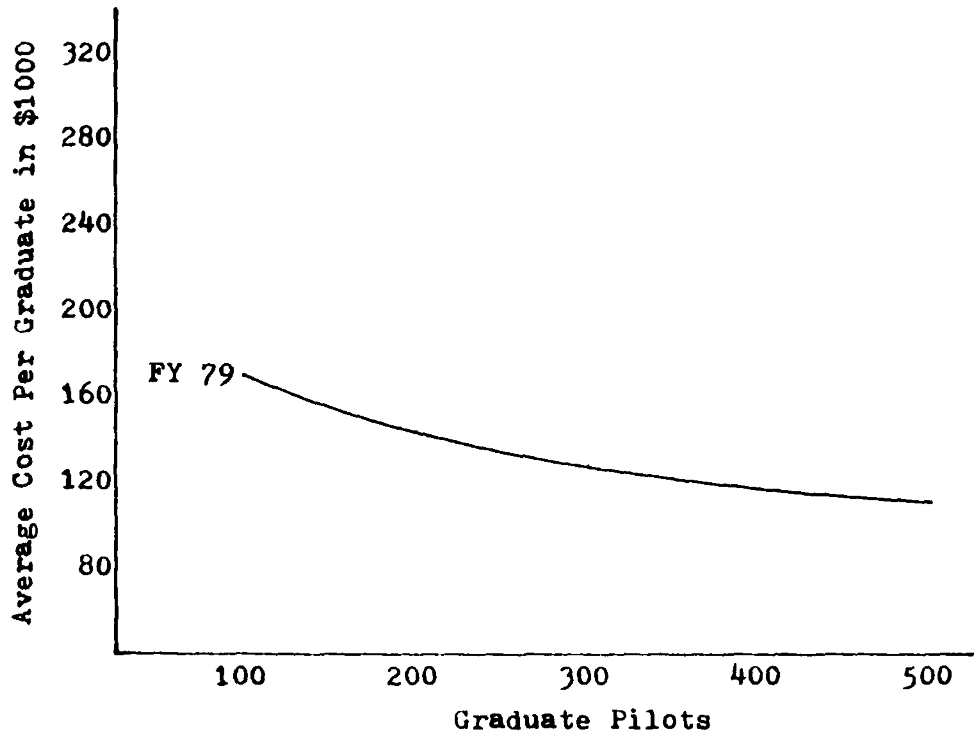

Fig. 10. Cross-Sectional Analysis

As the figures indicate, there is a definite inverse relationship between average cost per graduate pilot and the number of graduate pilots produced.

Time-Series Analysis

The time-series analysis used the regression technique on time-series average cost/graduate pilot observations from each training base in the group I and group III training programs over the years studied. The regression technique was also applied to the time-series aggregate average cost/graduate pilot observations. The four models (linear, quadradic, logarithmic, and power) used in the cross-sectional analysis were evaluated to determine the best fitting relationship for each set of time-series observations. The results from the individual base analyses are presented first followed by the results from the aggregate analysis.

Individual Bases. Table 8 presents the results of the regression program for each base. Like the cross-sectional results, the values for aR^2, F, and α are listed for each model for each base. A time-series analysis was not made on Randolph or Laredo AFB because both bases lacked a sufficient number of cost/output observations to obtain meaningful results. Laredo had a total of four observations and Randolph had a total of three observations.

TABLE 8

TIME-SERIES RESULTS FOR EACH BASE

Base	Linear			Quadradic			Logarithmic			Power		
	aR^2	F	α	aR^2	F	α	aR^2	F	α	aR^2	F	α
Columbus	0	.87	.39	0	1.02	.36	0	.83	.41	0	.70	.44
Craig	.74	21.39	.00	--	--	--	.80	29.46	.00	.78	25.80	.00
Laughlin	.64	15.50	.01	.71	21.01	.00	.65	15.94	.01	.55	10.60	.01
Moody	.97	184.06	.00	.99	234.21	.00	.99	513.77	.00	.99	900.93	.00
Reese	.95	113.05	.00	--	--	--	.95	125.90	.00	.96	164.33	.00
Vance	.81	30.50	.00	.86	27.85	.00	.85	39.57	.00	.86	47.72	.00
Webb	.66	10.55	.03	--	--	--	.70	12.89	.02	.69	12.39	.02
Williams	.93	99.45	.00	.93	100.46	.00	.94	109.77	.00	.92	76.39	.00

The results in Table 8 indicate that each base has at least one model which provides a good fitting relationship. The only exception is Columbus AFB. In Columbus' case, the aR^2 values of zero indicate that none of the variation in average cost is explained by graduate pilots produced. Table 8 also shows that the quadradic model does not provide a relationship between average cost and graduate pilots produced for Craig, Reese, or Webb AFB. This was due to the stepwise inclusion process of the computer program. The GRADSSQ term was not included in the final equation because the proportion of variance in COST explained by the GRADSSQ variable was less than one-tenth percent. This resulted in a simple linear relationship between graduate pilots and average cost.

The model with the largest values for aR^2 and F is the model that provides the best functional relationship between average costs and graduate pilots produced for each base. Using the values for aR^2 and the F-test, the models can be rank ordered according to their goodness of fit for each base. The number of times each model provides the "BEST" to the "WORST" fitting relationship is shown in Table 9.

Since none of the models determined a functional relationship for Columbus AFB, Table 9 applies to seven instead of eight time-series analyses. As indicated in

TABLE 9

RANK ORDERING OF FOUR MODELS FOR GOODNESS OF FIT
FOR SEVEN TIME-SERIES ANALYSES

Model	Goodness of Fit			
	Best	2d Best	3rd Best	Worst
Linear	0	0	5	2
Quadradic	1	2	1	3
Logarithmic	3	3	1	0
Power	3	2	0	2

Table 9, the logarithmic model provides either the best or second best functional relationship between average cost and graduate pilots produced in six out of the seven analyses or 86 percent of the time. Also, the power model provides either the best or second best functional relationship in five out of seven analyses or 71 percent of time. However, the power model provides the second best fitting relationship only 29 percent of the time compared to the logarithmic models 43 percent. Additionally, the power model provides the worst fitting relationship 29 percent of time compared to the logarithmic models zero percent. For these reasons, the logarithmic model was chosen as the best indicator of the functional relationship between average cost and graduate pilots produced for the time-series data considered.

The logarithmic model evaluated was

$$COST = e^{[A + B(GRADS)]} \tag{9}$$

where COST represented the average cost, GRADS represented the number of graduate pilots produced, A was the constant, B was the coefficient of GRADS, and (e) was approximately equal to 2.718. Table 10 presents a summary of the constants (A) and coefficients (B). It also presents the values for aR^2, F, and α for the logarithmic model for each base's time-series analysis.

TABLE 10

SUMMARY OF THE LOGARITHMIC MODEL FOR EACH BASE'S TIME-SERIES DATA

Base	Constant A	Coefficient B	aR^2	F	α
Craig	12.55	-.00326	.80	29.46	.00
Laughlin	12.16	-.00158	.65	15.94	.01
Moody	12.94	-.00381	.99	513.77	.00
Reese	12.69	-.00295	.95	125.90	.00
Vance	12.51	-.00279	.85	39.57	.00
Webb	12.00	-.00136	.70	12.89	.02
Williams	12.71	-.00266	.94	109.77	.00

The results in Table 10 show that the logarithmic model has an aR^2 value of greater than .80 for five out of

the seven bases. Webb and Laughlin are the only two bases with aR^2 values less than .80. In Webb's case (.70), the logarithmic model still provides the highest aR^2 value, and in Laughlin's case (.65), the logarithmic model provides the second highest aR^2 value.

Another result shows that the significance level (α) is less than .05 or the model is statistically significant at the 95 percent confidence level for all seven time-series analyses. In fact, α is less than or equal to .01; i.e., the regression model is statistically significant at the 99 percent level for six out of seven bases.

Another important observation from Table 10 is that the value of the model's coefficient (B) is negative for each set of the time-series data. This indicates that as the number of graduate pilots increase, the value for the exponent, A + B(GRADS), will get smaller and thus average cost (COST) will decrease. Figures 11 and 12 further illustrate this point. Although the average costs per graduate for a particular output differ between bases, all bases exhibit this inverse relationship between average costs and graduate pilots produced.

Aggregate Analysis. The aggregate analysis used the average cost/graduate pilot observations for each year based on total training costs and total number of graduate pilots produced. Only those bases included in the group I and

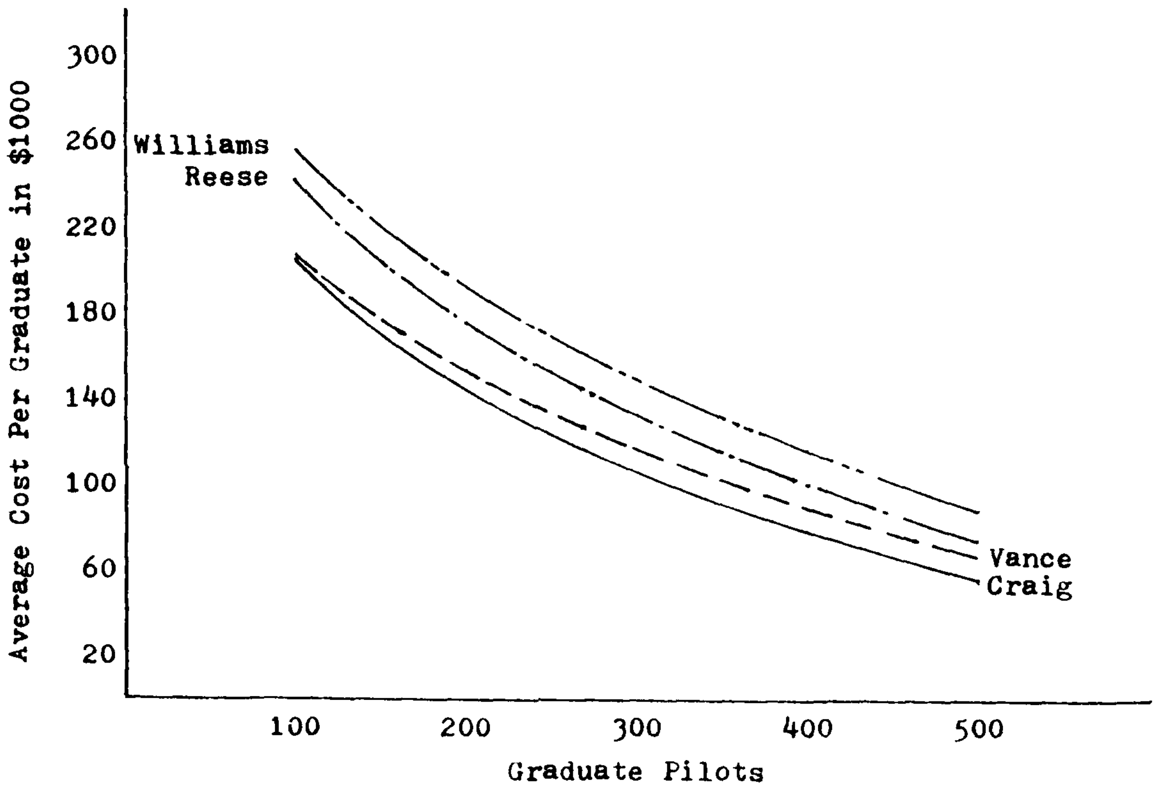

Fig. 11. Time-Series Analysis

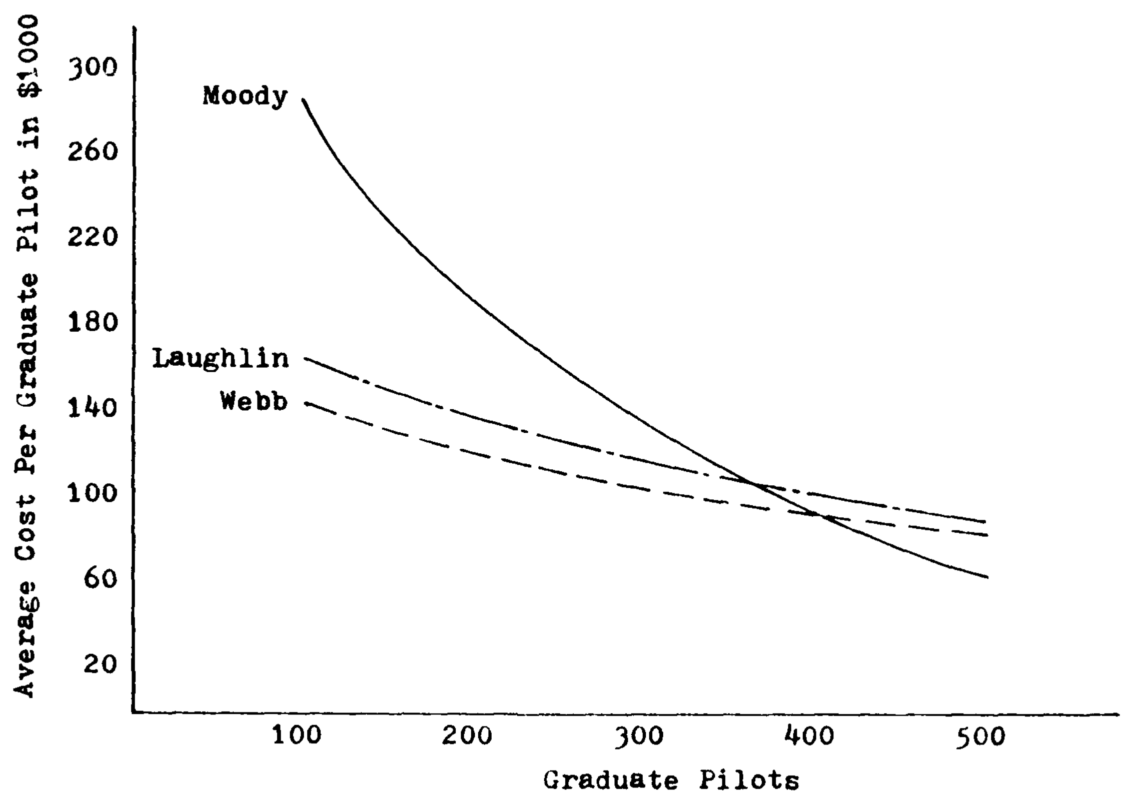

Fig. 12. Time-Series Analysis

group III training programs (see Table 2) through FY 76 were considered in the analysis. This was done to prevent the influence of technological changes due to the incorporation of the Instrument Flight Simulator (IFS) training program. The results of the regression analysis using the four models are shown in Table 11.

TABLE 11

AGGREGATE TIME-SERIES RESULTS

Model	aR^2	F	α
Linear	.95	110.62	.00
Quadradic	.94	48.72	.00
Logarithmic	.95	116.26	.00
Power	.91	64.45	.00

The results in Table 11 show that all models have an aR^2 greater than .90 and all models are significant at less than the .01 level. The results also show that there is very little difference between the goodness of fit for the linear and logarithmic models. Because the logarithmic model has the highest F value which makes it statistically more significant, it is the one that best explains the variation in average costs due to graduate pilots produced. The specific form of the model as a result of the regression analysis is

$$\text{COST} = e^{(12.39 - .000265\ \text{GRADS})} \tag{10}$$

This equation indicates that as the number of graduate pilots (GRADS) increase, the exponent of (e) becomes smaller and thus average cost (COST) decreases. Figure 13 is the graphical representation of equation (10) and further illustrates this inverse relationship between graduate pilots and average cost.

Comparison of Results to Hypotheses

The first hypothesis stated that economies of scale exist in undergraduate pilot training. The results of the cross-sectional and time-series analyses clearly indicate that this is a true statement.

In the cross-sectional analysis, the regression procedure resulted in the selection of the power model as the model which best represented the long run average cost curve for each fiscal year studied. For each fiscal year, the power model indicated that there was an inverse relationship between average cost and graduate pilots produced. In other words, as the number of graduate pilots produced increased the average cost per graduate pilot decreased. This verified the existence of economies of scale in the years studied.

In the time-series analysis, the regression procedure resulted in the selection of the logarithmic model as the model best representing the long run average cost curve for each pilot training base and for the aggregate of all

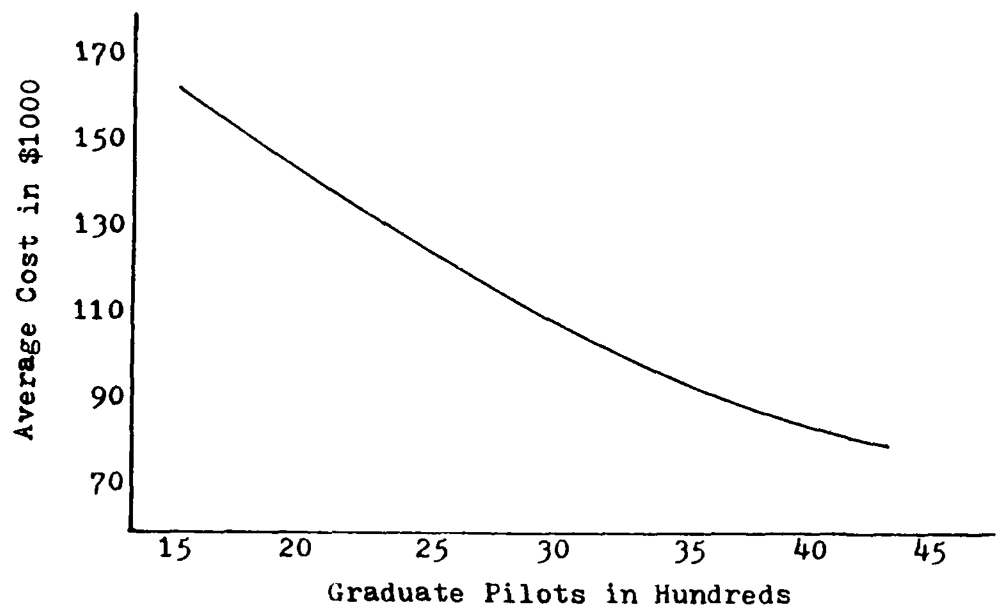

Fig. 13. Aggregate Time-Series Analysis

training bases. In all cases, the logarithmic model indicated an inverse relationship between average cost and number of graduate pilots produced. As in the cross-sectional analysis, this meant that as the number of graduate pilots increased, the average cost per graduate decreased. This verified the existence of economies of scale at each training base as well as for all training bases in the aggregate.

The second hypothesis stated that the consolidation of pilot training operations results in decreased unit costs for the output produced. The results of this study cannot directly confirm or deny this statement. However, the results do imply such a relationship.

As previously discussed, the time-series regression analysis for each base and for the aggregate of all bases verified that an inverse relationship existed between average costs and the number of graduate pilots produced. Since the average cost per graduate would decrease at each base as the number of graduate pilots produced increases, the implication can be drawn that by consolidating bases and thus producing more pilots with fewer bases the average costs would be reduced.

Thus, the results of this study verify that economies of scale exist in undergraduate pilot production, and imply that the consolidation of pilot training operations results in decreased unit costs.

Summary

This chapter was divided into two major sections. The first section analyzed the data and discussed the analysis procedure. The second section presented the results of the analysis and compared them to the study's two hypotheses.

In the first section, before a meaningful study could be made, the data was grouped, adjusted and some observations excluded to remove the changes in training cost caused by program and factor input price changes. To remove these influences, only those bases that had similar flying programs between FY 68 and FY 79 were included in the study. This study did not consider data prior to FY 68 due to its scarcity and unreliability. There were two adjustments made to the data: the one removed the training costs for the T-41 phase between FY 68 and FY 70 in order to get a broader data base, and the other adjusted for the increases in factor input prices. The Vance AFB observations and the Webb AFB observations from FY 74 to FY 76 were excluded from the cross-sectional analysis to prevent distorted results. Also, the Webb AFB observation from FY 74 was excluded from the time-series analysis for the same reason.

The second part of the analysis section discussed the regression analysis procedure. Four models (linear, quadradic, logarithmic, and power) were evaluated to

determine which model best explained the relationship between average cost and the number of graduate pilots produced. The two values used to determine which model best fit the empirical observations were the adjusted coefficient of determination and the F-test. The level of significance was used to determine how much confidence could be placed in the predictive ability of the models.

In the second section, the results of the computer analysis on both the cross-sectional and time-series data were presented. The cross-sectional analysis resulted in the selection of the power model as the one which best fit the cross-sectional data. For each set of cross-sectional data, the power model indicated that an inverse relationship existed between average cost and the number of graduate pilots produced. The time-series analysis resulted in the selection of the logarithmic model for both the data associated with the individual bases and the aggregate of all bases. In all cases, the logarithmic model also indicated that an inverse relationship existed between average costs and the number of graduate pilots produced.

The final portion of the results section compared the study's two hypotheses to the results of the computer analysis. The results confirmed the existence of economies of scale in undergraduate pilot production due to the decreasing long run average cost curves exhibited in both

the cross-sectional and time-series analyses. The decreasing long run average cost curves from the time-series analysis also implied that the consolidation of pilot training operations results in decreased unit costs for a specific quantity of pilot production.

The final chapter will summarize the entire study and present the conclusions reached through the analysis. Recommendations for further study will also be made.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

This study was undertaken to investigate the DOD's rationale for closing installations and/or deactivating units in order to reduce costs and conserve resources. The rationale of the DOD's actions is based on the principle of economies of scale without considering the possibility of diseconomies of scale. The research question to be answered was whether economies or diseconomies existed in a DOD production operation. In order to answer this question, the study concentrated on the production of undergraduate pilots within the Air Force because pilot training was an example of a production operation within the DOD. The two hypotheses examined were (1) economies of scale exist in the production of undergraduate pilots, and (2) the consolidation of pilot training operations results in decreased unit costs for the output produced.

Initially, the theory behind the economic principles of economies and diseconomies of scale were discussed. Economies of scale are the result of increased specialization and division of labor and improved technology. Diseconomies of scale are caused by the limitations on

managerial ability and information flow. The next area discussed how an organization could determine whether it was experiencing economies or diseconomies of scale. The two approaches presented for determining this were through an analysis of either an organization's production function or cost relationships. The production analysis approach used the production function which related the input factors to the output produced. The cost analysis approach used the cost/output observations to determine the long run average cost curve. Once the long run average cost curve was determined, an organization could tell whether it was producing its output in the range of economies or diseconomies. Because the cost analysis approach was recommended for organizations that had their production level determined externally, it was the approach chosen to examine pilot production. This approach was also chosen because the necessary cost/output data was obtainable.

Following the selection of the cost analysis approach, the survivor, engineering, and regression methods for determining an organization's long run average cost curve were presented. For this study, the regression method was chosen because it gave the best estimate of the functional relationship that existed between average cost and output.

The necessary cost and output data was obtained from historical records maintained at Headquarters Air Training Command. The total training costs and number of graduate pilots were accumulated by base for FY 68 through FY 79. Data for the years prior to FY 68 was not considered due to its scarcity and unreliability. This data was grouped into four different categories based on the number of flying hours involved in the training program. The study concentrated on two of these groups because of their similarity. These two groups were then adjusted for the effects of inflation and the effects of slight differences in training programs. The grouping and adjustment of the data minimized the effects of program and factor input price changes and thus enhanced the meaningfulness of the study. The analysis excluded certain cost/output observations for the same reason.

A multiple regression program was applied to both cross-sectional and time-series cost/output observations. The same program was applied to both types of data, and it evaluated four functional models to determine which model best fit the empirical observations. The four models evaluated were the linear, quadradic, logarithmic, and power.

The results of the cross-sectional analysis indicated that the power model provided the best or second best fitting relationship in seven out of eight cases or 87.5

percent of the time. Using the power model as the indicator of the functional relationship, the results revealed that an inverse relationship existed between average cost and the number of graduate pilots produced in all cases.

The time-series analysis evaluated the same four models as in the cross-sectional analysis but used time-series instead of cross-sectional data. A time-series analysis was conducted on each pilot training base and the aggregate of all training bases. The results of the analysis on each base revealed that the logarithmic model provided the best or second best fitting functional relationship in six out of seven cases or 86 percent of the time. The logarithmic model also provided the best fitting relationship for the aggregate of all bases. Using the logarithmic model as the best indicator of the functional relationship, the results showed that an inverse relationship existed between average cost and the number of graduate pilots produced in all cases.

Conclusions

The following conclusions are based on the analysis and results of this study.

When evaluating cross-sectional data to determine the long run average cost curve for undergraduate pilot training, the power model is a reasonable predictor of the

functional relationship between average cost and the number of graduate pilots produced.

When evaluating the time-series data for a particular pilot training base, the logarithmic model is a reasonable predictor of the functional relationship between average cost and the number of graduate pilots produced. The logarithmic model is also a reasonable predictor of this functional relationship when evaluating time-series data for the aggregate of all training bases.

Over the years considered, undergraduate pilot production was operating in the range where economies of scale existed on both the level of the individual training base and the aggregate of all training bases. In conjunction with this, none of the individual bases or the aggregate of all bases had reached the point in production where diseconomies had taken effect.

Because the industry was operating in the range of scale economies, the combining of operational units and/or closing of the pilot training bases resulted in a lower average cost per graduate pilot.

The time-series analysis produced a different long run average cost curve for each base, and the cross-sectional analysis produced a different long run average cost curve for each year. These differences resulted in varying rates of economies between bases and between years.

They also resulted in different average costs for a specific production level between bases and between years.

Recommendations

The following recommendations are based on the results and conclusions drawn from this study.

This study adjusted the training costs for factor input price changes by using a common price deflator for the purchase of government goods and services. To improve the accuracy of the resultant long run average cost curves, cost accumulation procedures should be changed to reflect the training costs associated with each input factor. The resultant costs could then be accurately adjusted for changes in input factor prices.

In addition to the above recommendation, variables such as regional wage rates and fuel costs should be added to the cross-sectional models to account for impacts on the average costs other than graduate pilots. This should also increase the accuracy of the predicted long run average cost curves.

Since all training bases displayed different long run average cost curves, the Air Training Command should make an attempt to accurately predict each base's curve. If this is accomplished, the curves should be used as an input to the decision process involving a base closure.

APPENDICES

APPENDIX A

SUMMARY OF UPT TRAINING COSTS AND GRADUATES BY BASE FY 68 THROUGH FY 79

	FY 68		FY 69		FY 70	
Base	Trng Costs	Grad	Trng Costs	Grad	Trng Costs	Grad
Columbus	--	--	--	--	--	--
Craig	$ 29,100,578	380	$ 29,830,225	334	$ 29,024,379	376
Laredo	27,523,901	338	30,509,632	361	34,103,461	431
Laughlin	33,354,464	412	33,609,531	430	34,574,711	411
Moody	29,623,768	384	31,405,678	330	32,322,066	417
Randolph	16,474,254	96	24,942,179	240	27,748,200	379
Reese	32,144,880	414	34,036,629	440	34,666,089	419
Vance	27,174,011	420	30,370,845	457	30,865,427	500
Webb	30,274,775	404	34,347,495	418	33,776,609	425
Williams	33,874,949	455	37,919,416	469	38,379,422	544
TOTALS	$259,550,000	3303	$286,970,000	3479	$295,460,000	3902

	FY 71		FY 72		FY 73	
Base	Trng Costs	Grad	Trng Costs	Grad	Trng Costs	Grad
Columbus	$ 37,840,120	395	$ 39,083,205	390	$ 40,033,637	316
Craig	32,209,224	332	34,143,079	365	34,387,968	319
Laredo	37,501,674	459	39,113,250	475	39,348,688	347
Laughlin	38,044,890	434	38,235,435	405	36,723,594	379
Moody	36,640,069	449	38,245,241	430	39,135,688	379
Randolph	23,484,106	370	--	--	--	--
Reese	37,306,906	437	38,752,674	456	38,786,009	385
Vance	33,310,399	475	33,767,973	462	30,479,578	328
Webb	37,240,311	413	38,201,530	423	35,680,499	348
Williams	43,669,303	558	45,383,811	577	44,553,657	493
TOTALS	$357,250,000	4322	$357,250,000	4322	$344,930,000	3983

	FY 74		FY 75		FY 76	
Base	Trng Costs	Grad	Trng Costs	Grad	Trng Costs	Grad
Columbus	$ 58,204,444	326	$ 53,335,918	296	$ 53,001,366	229
Craig	48,882,690	197	48,125,012	264	45,929,700	207
Laughlin	55,056,663	320	52,690,999	279	44,270,186	261
Moody	52,897,719	261	50,710,384	254	--	--
Reese	51,618,956	317	51,351,152	257	51,543,586	256
Vance	53,270,625	297	45,404,358	294	45,228,885	250
Webb	77,952,882	226	33,660,143	179	25,761,571	165
Williams	63,039,640	353	61,802,290	360	60,033,288	328
TOTALS	$460,920,000	2297	$397,080,000	2183	$325,770,000	1696

	FY 77		FY 78		FY 79	
Base	Trng Costs	Grad	Trng Costs	Grad	Trng Costs	Grad
Columbus	$ 52,728,012	238	$ 35,858,553	187	$ 39,255,478	148
Craig	36,916,368	188	--	--	--	--
Laughlin	32,833,383	152	31,042,583	153	37,626,041	146
Reese	57,553,765	262	59,837,328	272	60,826,205	278
Vance	48,650,100	240	53,585,024	233	58,130,747	276
Williams	58,927,855	295	61,653,964	290	64,025,577	284
TOTALS	$287,610,000	1375	$241,980,000	1135	$259,860,000	1132

APPENDIX B

AVERAGE COST PER GRADUATE BY BASE FY 68 THROUGH FY 70, FY 73 THROUGH FY 79

Base	Costs (72$)	T-41 Adj	Grad	Cost/Grad
		FY 68		
Craig	$ 38,089,762	$ 36,627,115	380	$ 96,387
Laredo	36,026,048	34,642,648	338	102,493
Laughlin	43,657,675	41,981,221	412	101,896
Moody	38,774,565	37,285,622	384	97,098
Randolph	21,563,160	20,735,134	96	215,991
Reese	42,074,450	40,458,791	414	97,727
Vance	35,568,077	34,202,263	420	81,434
Webb	39,626,669	38,105,005	404	94,319
Williams	44,338,938	42,636,323	455	93,706
TOTALS	$339,730,000	$326,680,000	3303	$98,904
		FY 69		
Craig	$ 37,287,781	$ 35,855,930	334	$107,353
Laredo	38,137,040	36,672,578	361	101,586
Laughlin	42,011,914	40,398,656	430	93,950
Moody	39,257,098	37,749,625	330	114,393
Randolph	31,177,724	29,980,499	240	124,919
Reese	42,545,786	40,912,028	440	92,982
Vance	37,963,556	36,505,756	457	79,881
Webb	42,934,369	41,285,689	418	98,770
Williams	47,399,270	45,579,138	469	97,184
TOTALS	$358,710,000	$344,940,000	3479	$99,149

Base	Costs (72$)	T-41 Adj	Grad	Cost/Grad
		FY 70		
Craig	$ 33,593,031	$ 32,303,059	376	$85,912
Laredo	39,471,598	37,955,885	431	88,065
Laughlin	40,017,027	38,480,373	411	93,626
Moody	37,409,799	35,973,262	417	86,267
Randolph	32,115,972	30,882,719	379	81,485
Reese	40,122,788	38,582,073	419	92,081
Vance	35,723,874	34,352,077	500	68,704
Webb	39,093,297	37,592,115	425	88,452
Williams	44,420,627	42,714,875	544	78,520
TOTALS	$341,970,000	$328,840,000	3902	$84,274
		FY 73		
Columbus	$ 37,838,976		316	$119,744
Craig	32,502,805		319	101,890
Laredo	37,191,577		347	107,180
Laughlin	34,710,391		379	91,584
Moody	36,990,253		379	97,600
Reese	36,659,744		385	95,220
Vance	28,808,675		328	87,831
Webb	33,724,479		348	96,909
Williams	42,111,207		493	85,418
TOTALS	$320,540,000		3294	$97,310

Base	Costs (72$)	Grad	Cost/Grad
	FY 74		
Columbus	$ 45,650,544	326	$140,032
Craig	38,339,365	197	194,616
Laughlin	43,181,696	320	134,943
Moody	41,488,407	261	158,959
Reese	40,485,456	317	127,714
Vance	41,780,882	297	140,676
Webb	61,139,515	226	270,529
Williams	49,442,855	353	140,065
+ TOTALS	$300,370,000	2071	$145,040
	FY 75		
Columbus	$ 41,832,093	296	$141,325
Craig	37,745,107	264	142,974
Laughlin	41,326,274	279	148,123
Moody	39,772,850	254	156,586
Reese	40,275,413	294	121,127
Webb	26,400,112	179	147,487
Williams	48,472,384	360	134,646
TOTALS	$311,440,000	2183	$142,660

+ Does not include data from Webb AFB.

Base	Costs (72$)	Grad	Cost/Grad
	FY 76		
Columbus	$ 39,376,944	229	$171,952
Craig	34,123,105	207	164,846
Laughlin	32,890,183	261	126,016
Reese	38,293,897	256	149,586
Vance	33,602,441	250	134,410
Webb	19,139,354	165	115,996
Williams	44,601,254	328	135,979
TOTALS	$242,030,000	1696	$142,710
	FY 77		
Columbus	$ 36,718,671	238	$154,280
Craig	25,707,777	188	136,743
Laughlin	22,864,473	152	150,424
* Reese	40,079,217	262	152,974
Vance	33,878,900	240	141,162
Williams	41,036,111	295	139,105
TOTALS	$200,290,000	1375	$145,670

* Indicates bases using IFS training program.

	Base	Costs (72$)	Grad	Cost/Grad
		FY 78		
	Columbus	$ 23,164,440	187	$123,874
	Laughlin	20,053,348	153	131,068
*	Reese	38,654,605	272	142,113
*	Vance	34,615,649	233	148,565
*	Williams	39,828,142	290	137,338
	TOTALS	$156,320,000	1135	$137,730
		FY 79		
	Columbus	$ 23,422,123	148	$158,258
*	Laughlin	22,449,905	146	153,766
*	Reese	36,292,485	278	130,549
*	Vance	34,684,217	276	125,667
*	Williams	38,201,418	284	134,512
	TOTALS	$155,050,000	1132	$136,970

* Indicates bases using IFS training program.

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